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Analysis of Eight Facilities: Operating and Cost Data for In-Vessel Composting

Camp, Dresser and McKee, Boston, MA

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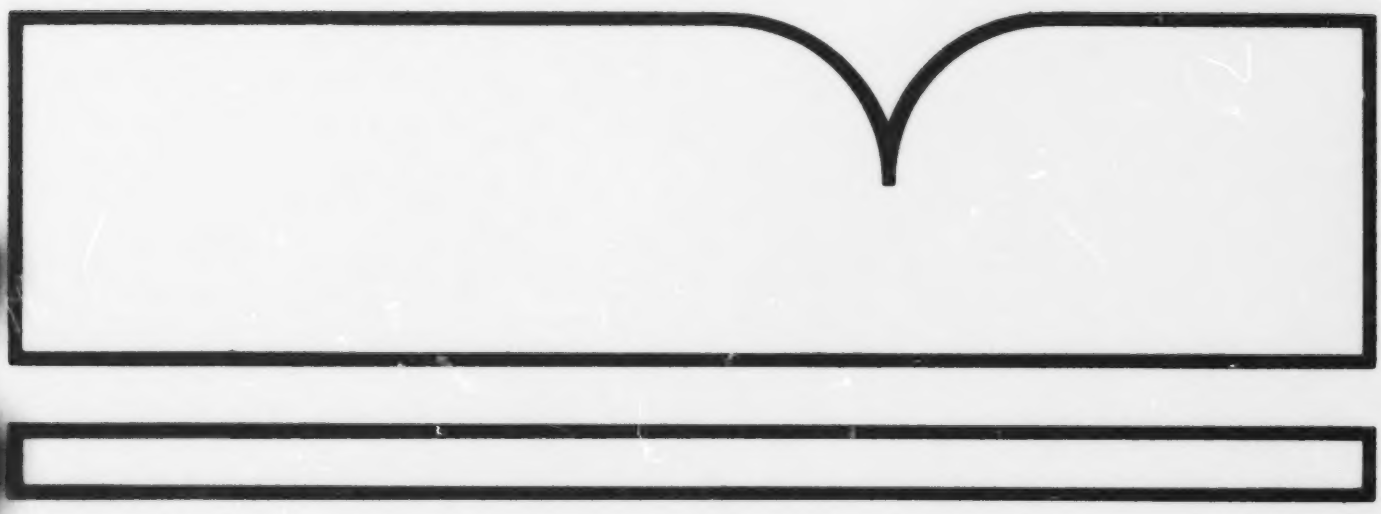

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16. ABSTRACT

Operating experiences and cost data gathered from site visits of eight, full scale, operating in-vessel sewage sludge composting facilities was summarized. The facilities visited represented the six in-vessel equipment suppliers who had full scale, operating plants in the U.S. at the time: American Bio Tech at Schenectady, NY; Ashbrook-Simon-Hartley at Newberg, OR; Fairfield (through Compost Systems Co.) at Plattsburgh, NY; Paygro (through Compost Systems Co.) at Akron, OH; Purac Engineering at Cape May County, NJ and Sarasota, FL; and Taulman-Weiss at Clayton County, GA and Portland, OR. Examples of both large and small plants were visited for Purac and Taulman-Weiss.

As might be expected for any new, large scale, mechanically complex technology, these facilities had some operational problems. Odor problems in particular were more difficult to predict and control than anticipated during design. Difficulty with materials handling systems was the other major problem, but was being overcome on a site-by-site basis. → Con't on Pg. 43

These facilities were processing from 1.3 to 44 dry tons of sludge per day at operating costs from $76 to $430 per dry ton. These costs exhibited a strong economy of scale.

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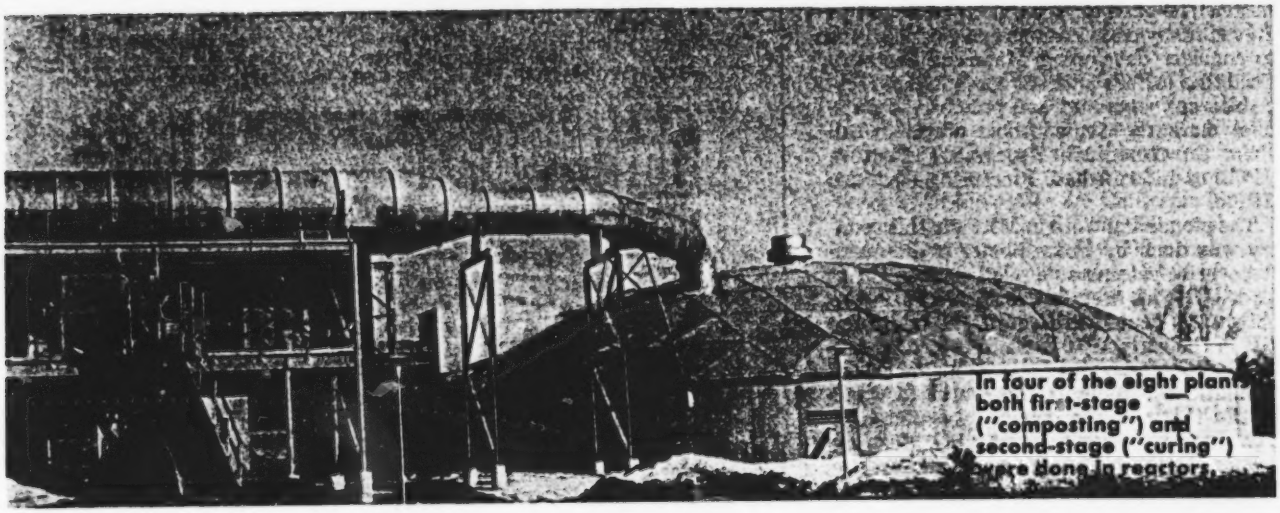

In four of the eight plants, both first-stage ("composting") and second-stage ("curing") were done in reactors.

Sludge composting installations provide valuable data to improve design and materials handling efficiency.

John Johnston, John F. Donovan and Albert B. Pincince

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DURING THE LAST 15 years, composting has grown in popularity as a sludge management technique, in part due to higher costs and greater environmental concerns often associated with alternative methods. Compared to static pile and windrow composting operations, in-vessel systems promise a more stabilized and consistent product, smaller space requirements, and better containment and control of odors. Because in-vessel composting systems are new in this country, however, there is relatively little information available on the operation and costs of actual systems.

With funding by the U.S. Environmental Protection Agency, Camp Dresser and McKee Inc. is conducting a technology evaluation of in-vessel composting. The purposes of this project are to collect, evaluate, and disseminate information on full-scale in-vessel composting systems and to provide guidance on the parameters important in the procurement, selection, design, and operation of a successful in-vessel composting project. A guidance document prepared with information obtained from this project will be published by EPA in the Fall of 1989.

This article presents some of the operating and cost data that were gathered during site visits to eight operating facilities in the period from April through November of 1988. (Unless otherwise noted, the information presented below was true at the time of the site visit. Readers desiring further information should contact the facilities directly.) Odors and materials-handling were posing problems for these systems, but all of the plants surveyed had been shown to be capable of making usable compost products.

SYSTEM STATUS

Basic information on the eight plants visited is summarized in Table 1. All six in-vessel equipment suppliers with full-scale installations in the U.S. were represented. For two suppliers—Taulman-Weiss and Purac—examples of both large and small plants were included.

In four of the eight plants, both "composting" and "curing" (i.e., first-stage and second-stage composting) were done in reactors. At two plants, in-vessel composting was followed by aerated static pile curing. No formal curing step was employed at two plants. At most plants, the composted material was stored unaerated, for some additional minimum period of time before release to the public. The minimum storage times were generally established by state regulatory agencies.

The status of each composting plant at the time of the site visit is shown in Table 2. The completion of acceptance testing and start of "commercial" operations occurred from 5 to

11 months after the start-up dates shown in the table.

Since start-up, many of the plants have been shut down for modifications or repairs. The odor control and aeration systems have been modified at Cape May. The Schenectady plant was taken out of service for structural repairs and upgrading of the odor control system. Operations at Newberg have been interrupted twice for structural repairs. The Portland plant was taken out of service for a month in 1988 so that miscellaneous modifications could be accomplished and so that the waste activated sludge storage lagoon could be dredged.

Only three plants—Clayton County, Plattsburgh, and Sarasota—were processing all of the sludge available or intended for each plant. The processing rates of the other five facilities were limited for one reason or another. The Akron plant was operating at reduced capacity to ameliorate local odors while new odor control equipment was being piloted. At Cape May, the new odor control system was in place, but return to full plant capacity was being done in stages under the direction of regulatory authorities. The Portland plant has been hampered by mechanical problems of various kinds that have prevented simultaneous operation of all six reactors for extended lengths of time. The Newberg plant was conducting acceptance testing at the time of the site visit. It has since been shut down because of a structural failure. The acceptance testing at Schenectady has been completed, but the plant was out of service for correction of structural problems and upgrading of the odor control system.

Design capacities and actual sludge processing rates are also shown in Table 2. At Cape May, the cure reactor was converted into a first-stage composting reactor when aerated static pile curing was initiated. This modification increased the plant capacity from 12 dry tpd as designed to 20 dry tpd.

PERFORMANCE

All of the plants were easily meeting the EPA time-temperature requirement for a pathogen-reducing process (55 C for 3 days) in the first stage reactor. Other performance data for the eight plants are shown in Table 3.

All of the plants use sawdust as amendment. Akron uses shredded bark as well. With the exception of Sarasota, all of the plants are using a larger fraction of amendment in their mix ratios than was anticipated in design. Reasons cited for increasing the amendment were to improve the handling characteristics of the mix, to increase the porosity of the mix, and/or to compensate for mix components with higher moisture contents than expected. In practice, the creation of an acceptable mix has been an empirical process that depends on the particle size distributions and textures of the amendment and recycle materials, as well as their moisture contents. Sawdust costs ranged from $3 to $14.25 per cubic yard.

The solids content of the composted material increased by less than 5 to over 20 percentage points in the first-stage reactor. The increase in solids content was a function of both the aeration rate per unit volume of reactor and the "plug flow" detention time of the material in the reactor. The solids contents of compost products (before unaerated storage) ranged from 40 to 71 percent.

Marketing success varied from plant to plant. Every plant experienced a period of product accumulation at the beginning of operations. The reasons for the initial accumulation of compost included delays in getting state permits for product distribution, unwillingness on the part of brokers or users to contract for material of varying quality and production rates, and/or low initial market demand. How each facility dealt with this problem depended mainly on the amount of room available at the site. Sarasota, for instance, with essentially no storage space at the plant site, paid to have the compost hauled away and applied to land. On the other hand, Portland had sufficient space

Solids content of the composted material increased by less than 5 to over 20 percentage points in the first-stage reactor.

Table 1. Plant Data

Location	Type of Reactor	Supplier	System Configuration First Stage	System Configuration Second Stage
Akron, OH	Rectangular agitated bin	Compost Systems Co. (Payoro)	In-vessel	None (aerated curing under study)
Cape May County, NJ	Rectangular vertical reactor	Purac Engineering	In-vessel	Aerated static pile[1]
Clayton County, GA	Cylindrical vertical reactor	Taulman-Weiss	In-vessel	In-vessel
Newberg, OR	Rectangular horizontal tunnel	Ashbrook-Simon-Hartley	In-vessel	Aerated static pile
Plattsburgh, NY	Circular agitated bin	Compost Systems Co. (Fairfield)	In-vessel	None
Portland, OR	Cylindrical vertical reactor	Taulman-Weiss	In-vessel	In-vessel
Sarasota, FL	Rectangular vertical reactor	Purac Engineering	In-vessel	In-vessel
Schenectady, NY	Rectangular vertical reactor	American Bio Tech	In-vessel	In-vessel

Notes:
[1]*System constructed with in-vessel curing but changed to configuration shown in 1987-88.*

Table 2. System Status at Time of Site Visit

Location	Start-up Date	System Status	Sludge Processing Rate (dry tpd) Design	Actual
Akron, OH	Dec. 86	Operating at reduced capacity because of current odor problems	73	25
Cape May County, NJ	May 85[2]	Operating at reduced capacity because of past odor problems	20 (12.1)[3]	11 11
Clayton County, GA	Aug. 86	Processing all the sludge available	20	11
Newberg, OR	Aug. 87	Undergoing acceptance testing	3.5	—
Plattsburgh, NY	Mar. 86	Processing all the sludge available	34	20
Portland, OR	Mar. 85	Operating at reduced capacity because of mechanical problems	60	26[4]
Sarasota, FL	Aug. 87	Processing all the sludge available	6.5	4.5[5]
Schenectady, NY	July 87	Shut down for modifications to structure and odor control systems	15	—

Notes:
[1]*Seven day/week basis. Actual loading is 44 dtpd, 4 d/wk.*
[2]*Start-up date for original configuration.*
[3]*Plant modifications made in 1987-88 increased the capacity to 20 dry tpd by adding aerated static pile curing and converting the existing cure reactor to a first-stage composting reactor.*
[4]*Average for first six months of 1988.*
[5]*Annual average, 3.9 dtpd in summer; 4.7 dtpd in winter.*

Table 3. Performance Data

Location	Volumetric Mix Ratio Sludge/Amendment/Recycle	Sludge	Solids Content Initial Mix	(% by weight) First Stage	Second Stage
Akron, OH	1/0.4/0.2	20-28 (avg: 25)	35-40	38-40	40-45
Cape May County, NJ	1/0.6/1	20-30 (avg: 23)	37	53-65	—
Clayton County, GA	1/1.2/1.2	16-18	33-40	33-44	—
Newberg, OR[2]	1/0.5/7.5	16-18	33-40	33-44	—
Plattsburgh, NY	1/1.2/3.3	20-28 (avg: 25)	35-40	38-40	40-45
Portland, OR	1/1.6/0.6	23-28 (avg: 25)	35-40	38-40	40-45
Sarasota, FL	1/0.6/2.1	20-28 (avg: 25)	35-39	—	—
Schenectady, NY	—	20-28 (avg: 25)	35-39	—	—

Notes:
[1]*Sludge / bark / sawdust / recycle*
[2]*System was undergoing acceptance testing at time of site visit. Data shown were collected later in the test (Sept-Oct 88) after the site visit.*

available onsite to store an inventory equivalent to two years of production.

At three of the plants—Clayton County, Portland and Akron—compost marketing was the responsibility of a subsidiary of the equipment supplier. The remaining plants were seeking or considering contracts with brokers.

The two largest user groups were landscape contractors and government agencies, who used the compost at parks, schools, highways, and landfills (as cover material). Golf courses and homeowners were taking significant quantities of compost from some plants. Local nursery industries have generally expressed interest in the product, but typically have purchased only small quantities to date for testing purposes. Compost prices varied from $2 to $19 per cubic yard, depending on local pricing policies and the quantities of compost purchased.

PROBLEM AREAS

The two major problem areas experienced by most or all of the plants surveyed were odor control and materials handling.

Of the eight facilities visited, five had records of serious odor complaints. A sixth plant had received minor odor complaints. All six plants with odor problems have operational odor control systems. The types of systems employed included wet scrubbers (one- and two-stage), ozone contact, a compost filter, and bubbling the odorous gases through water. Generation of odors did not appear to be related to the specific composting technology used.

There were several common factors that contributed to the odor problems at these plants. In at least three cases, site characteristics such as local topography, weather conditions, and the proximity of neighbors exacerbated odor problems. At some facilities, the odor control technology installed was ineffective at removing the odors or was undersized. Uncontrolled odor sources such as storage piles and open doors in the process building contributed to odor releases at several plants. The characteristics of the sludge being composted may also be an important factor. At the two plants that did not receive complaints (Portland and Newberg), the sludge being composted was relatively stable compared to the sludges at the other six facilities. The sludge at Portland was anaerobically digested prior to composting. At Newberg, the sludge was taken from an underloaded oxidation ditch with a long solids detention time.

At the time of the site visits, one plant had modified its odor control system extensively and four other plants were planning modifications. Two-stage wet chemical scrubbing was the technology most commonly being considered.

Problems with materials-handling systems were experienced at nearly every plant. Some commonly encountered problems are described below. Conveying systems used at the various plants include flat belts, cleated belts, drag chains, and screws (with and

without center shafts).

Spillage, particularly at transfer points, was a common problem where belt conveyors were used. Incidental spillage was usually controlled by adjusting belt speeds, providing or modifying scrapers and cleaners, and/or by installing collection pans. At Akron, where sludge adhering to the belt material was the cause of spillage, dusting the belt with sawdust prior to loading it with sludge greatly reduced the problem.

Drag chains at several plants experienced jamming problems caused by flights that were too large or by inadequate clearance between the flights and the drag chain housing. Reducing the cross-sectional areas of the flights usually alleviated this problem.

Plugging of chutes and funnels was also a common problem. Solutions to these problems were usually site-specific. Plant operators universally recommended monitoring these locations with motion detectors tied into the central computer system controlling the materials-handling system.

Outfeed devices have presented problems at several plants with vertical reactors. These plants use screw devices adapted from other applications such as sawdust silos. The most common problem reported was excessive wear on the screw whenever screw flights were not hard-surfaced. Schenectady and Portland have both experienced drive mechanism problems, although the nature of these problems and the designs of the screws are different.

COSTS

Operating costs and manpower needs for the eight plants are shown in Table 4.

Operating schedules and the number of operators required at the various plants were heavily dependent on the capabilities of the materials-handling equipment. For instance, operations staffs were smaller where the reactors could be loaded in one shift per day rather than two.

Operations personnel at most plants worked exclusively at the compost facility. Maintenance personnel at five facilities was provided by the wastewater treatment plant associated with the compost plant or by a centralized maintenance organization. Included in the "Other" category in Table 4 are supervisors, laboratory technicians, and clerical workers.

Annual operations and maintenance costs are shown in Table 4. Unless otherwise noted, the values shown reflect the 1988 budgets of the various facilities. (Because of their limited operating experiences, costs are not available for the Newberg and Schenectady plants.) Based on the sludge processing rates reported during the site visits, estimates were made of the quantity of sludge to be processed during the year. This was used to calculate the operations cost per dry ton of sludge processed. It is interesting to note that these costs exhibited an economy of scale, as illustrated in Figure 1. The plants with design capacities less than 15 dry tpd had "per ton" costs that were significantly greater than plants with design capacities greater than 15 dry tpd.

CONCLUSIONS

In-vessel composting is proving to be an effective method of producing an environmentally useful product from waste sludge. The compost being produced at all of the plants surveyed had been approved by state agencies for public use except application on food crops. While costs and operational problems have generally been greater than anticipated during design, this is to be expected in the implementation of any new, large-scale technology. As the lessons learned at these early installations are incorporated into new designs and operations, mechanical problems and costs will decline. In the future, this technology should see wide application. ■

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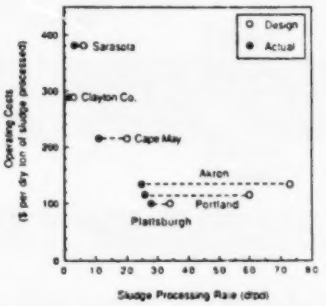
Authors are, respectively, senior environmental engineer, associate and vice president of Camp Dresser and McKee, based in Boston, Massachusetts.

Figure 1: Operating Costs as a Function of Sludge Processing Rate



Operating costs (per dry ton of sludge actually processed) are plotted against both plant size (expressed as design capacity and shown with open circles) and actual processing rate (solid circles).

Table 4. Operations and Cost Data

Location	Number of Personnel: Operations	Maintenance	Other	Operating Costs: Total Annual ($1000/yr)	Per ton of sludge processed ($/dry ton, approx)
Akron, OH	8	4	2	1225[1]	135
Cape May County, NJ	9[2]	3	2	1038[3]	215[4]
Clayton County, GA	2	Maintenance by WWTP staff	1	148	290
Newberg, OR[5]	1.5[6]	Maintenance by WWTP staff	0	—	—
Plattsburgh, NY	4	3	1	1020[7]	100
Portland, OR	6[8]	3[8]	1	1100	115
Sarasota, FL	3	2.5[8]	1	600[7]	380
Schenectady, NY	3	Maintenance by WWTP staff	1	—	—

Notes:
[1] *1987 expenditures.*
[2] *Not including 5 summer employees used for groundskeeping and utility work.*
[3] *1989 budget estimate.*
[4] *Based on expected sludge processing rate of 13.3 dtpd assuming that the plant is allowed to move to the next stage of operation. Based on actual expenditures of $474,000 (Jan.-Sept. 88) and actual sludge processing of 1200 dt (Apr.-Sept.), the unit cost was $395/dry ton.*
[5] *Plant undergoing acceptance testing.*
[6] *Operators rotate through composting plant. Value shown is an estimate of equivalent personnel.*
[7] *Not including sludge disposal costs.*
[8] *Maintenance by WWTP staff. Value shown is estimate of equivalent personnel.*